

# ECOLOGY, ENVIRONMENT AND CONSERVATION

## VOL. 24 (3) : 2018

### CONTENTS

- 1009–1017 Diversity and Abundance of Butterfli (Lepidoptera rhopalocera) in the city Garden of Banda Aceh, Indonesia  
—*Suwarno, Irla Hanum, Yekki Yasmin, Saida Rasnovi and Dahelmi*
- 1018–1026 Microwave digestion and analysis of selected heavy metals in the sediments  
—*Jolly Jacob and S. Shetye*
- 1027–1032 Determination of taxation indicators and carbon and nitrogen sequestration of phytomass of scots pine (*Pinus sylvestris* L.) in the green belt of the city of Astana  
—*Assel R. Tumenbayeva, Dani N. Sarsekova and Stanisaw Maek*
- 1033–1042 Changes in the fatty acid compositions of Tareeh, a fermented fish product of *Sardinella albelli* fish locally known as Oom in the Kingdom of Bahrain  
—*Afnan M. Freije, Aysha M. Al-Kaabi, Salwa M. Al-Thawadi Kareema M. Saleh and Ali S. Bin Thani*
- 1043–1047 First record of use *Fusarium proliferatum* fungi in direct treatment to control the adult of wheat flour *Tribolium confusum*, as well as, use the entomopathogenic fungi *Beauveria bassiana*  
—*Laith K. Tawfeeq Al-Ani, May I. Yonus, Beadaa Abdalqader Mahdii, Marwa A. Omer, Jameelah Kadham Taher, Shaymaa Fadhel Abbas Albaayit and Saif Basheer Al-Khoja*
- 1048–1052 Research of development trends in the field of soil fertility restoration  
—*Alexander V. Turyansky, Ekaterina G. Kotlyarova, Sergey D. Litsukov, Alla I. Titovskaya and Alexander V. Akinchin*
- 1053–1058 Optimization transport of Paracetamol through chloroform by bulk liquid membrane technique  
—*Refinel, Imelda, Viola Rahmadhian and Deswati*
- 1059–1064 Combustion intensity of *Cistus* plant formations in the region of Tlemcen (Algeria)  
—*Smoin El-Amine Henaoui and Mohammed Bouazza*
- 1065–1068 Studying state of soils in South shetpe chalk deposit  
—*Ainur Zhidebayeva, Gusman Kenzhetayev, Samal Syrlybekkyzy, Ainazhan Maratovna Aitimova, Botakoz Suleimenova and Nurgul Janaliyeva*
- 1069–1075 Analysis of puddles in Swamp areas of Banyuasin District using the image Lands at 8 by NDWI method  
—*Indrayani, Erika Buchari, Dinar D.A. Putranto and Edward Saleh*
- 1076–1084 Heavy metal content, cell structure and pigment of *Halimeda opuntia* (Linnaeus) J.V. Lamouroux from Totok Bay and Blongko Waters, North Sulawesi, Indonesia  
—*Desy Maria Helena Mantiri, Rene Charles Kepel, Billy Theodorus Wagey and Nasprianto*
- 1085–1091 Comparative evaluation of the chemical composition and yield of barnyard millet depending on climate conditions, sowing times and the development phase under the conditions of the steppe zone of North Kazakhstan  
—*Nurbolat Mukhanov, Nurlan Serepayev, Vladimir Zotikov, Gani Stybayev, Aliya Baitelenova, Adilbek Nogayev and Oktyabr Khurmetbek*
- 1092–1103 Poverty and local potentials  
—*Elsina Titaley, Sanggar Kanto, Darsono Wisadirana and Mardiyono Mardiyono*
- 1104–1108 Economic valuation of water resources in gasing watershed in Talang Kelapa Sub-district, South Sumatera, Indonesia  
—*Septarianti Arini, Dinar Dwi Anugerah Putranto and Dan Sarino*

- 
- 1109–1114 **Tunggu Tubang women empowerment effects in the development of ecotourism in Fajar Bulan Village, Semende Sub-district, Muara Enim district, South Sumatera-Indonesia**  
—*Eni Murdiati, Sriati, Alfitri and M. Ridhah Taqwa*
- 1115–1122 **Institutional representation of forest and land conservation in upper Bengawan Solowatershed Indonesia**  
—*Trisni Utami, Prabang Setyono, Ismi D.A. Nurhaeni and Suntoro*
- 1123–1130 **First study on waterbirds wintering at the southern Mekhada marsh (North-East Algerian Ramsar site)**  
—*Bourafa Yamen, Bouchecker Abdenmour, Seddik Sihem, Maazi Mohamed El Cherif and Houhamdi Moussa*
- 1131–1136 **The influence of three leaves as feed to life cycle of *Graphium agamemnon* (Lepidoptera : Papilionidae)**  
—*Yayan Sanjaya, Suhara and Mimi Halimah*
- 1137–1143 **Diversity of functional soil arthropods in tropical rainforest super wet Indonesia**  
—*Fenky Marsandi, Hermansah, Agustian and Syafrimen Yasin*
- 1144–1148 **Biodiversity conservation of the main species of woody and shrubby plants in the forests of Western Siberia (Tomsk region), Russia**  
—*Alexey Myasnikov*
- 1149–1156 **Genotoxicity on *BUFO marinus* Linnaeus (Anura: Bufonidae) from selected rivers in Cebu Province, Philippines**  
—*Carme Irene I. Pelone, Ma. Cherry Ann A. Gorgonio, Emmylou B. Hayag and Ma. Kristina O. Paler*
- 1157–1160 **The amount of artificial light pollution in the region of six municipality, Tehran, Iran**  
—*Nasrin Hosseini and Mozhgan Zaeimdar*
- 1161–1163 **Effect of foliar spray of different nutrient application on growth and yield attributing characters of Bt cotton**  
—*Avinash Borade, D.V. Durge, M.D. Jadhav and D.M. Ransing*
- 1164–1168 **Evaluating and measuring the amount of heavy metals (Cd, Hg, Pb) in surface runoff in the region six Tehran, Iran**  
—*Nillofar Vaziri Sani and Mozhgan Zaeimdar*
- 1169–1173 **An evaluation of teachers' awareness level of air pollution impacts on students' training quality in Tehran primary Schools and its comparison with other Schools**  
—*Mersedeh Tivay and Mozhgan Zaeimdar*
- 1174–1179 **Shoreline demarcation on Tirunelveli coast analysis moving boundaries using R (AMBUR) statistics**  
—*A. Dennis, L. Senthilnathan, M. Machendiranathan and R. Ranith*
- 1180–1190 **Waters chemical contamination analysis regarding communities floating fish cage at lake Toba, North Sumatera, Indonesia**  
—*Mindo Tua Siagian and Ivan Elisabeth Purba*
- 1191–1200 **Evaluation of new towns of Tehran based on Urban development indicators**  
—*Meysam Adinelu Fard, Bahram Aminzadeh and Davod Azizi*
- 1201–1209 **An evaluation of fish fauna and the population of a Korean endangered freshwater fish, *Brachymystax lenok tsinlingensis*, in Korea: II. Bonghwa Habitat**  
—*Dohun Lim and Yoonjin Lee*
- 1210–1229 **Fate, transport, and toxicity of veterinary antimicrobials with an insight on Africa: A review**  
—*Martha N. Chollom, Sudesh Rathilal, Feroz M. Swalaha and Babatunde F. Bakare*

- 
- 1230–1234 Virulence factors in *Aeromonas* Spp. from environmental water samples in Northern Thailand  
—Kannipa Tasanapak, Siriwat Kucharoenphaibul, Jintana Wongwigkarn, Kunsuda Nimanussornkul, Sutthirat Sitthisak and Plykaeow Chaibenjawong
- 1235–1238 Comparison of the protective effect and anti-diabetic and anti-pain of two species of medicinal herbs of Plantaginaceae and compositae  
—A. Hsanvand, M. Rezaei, A. Loni and V. Yakhchi
- 1239–1243 Anti-inflammatory effects and treatment of hydro alcoholic extract of medicinal plant *Althea officinalis* L. for the treatment of Burn wounds  
—A. Hsanvand, M. Rezaei, V. Yakhchi and A. Loni
- 1244–1247 The study of protein electrophoresis and comparison with proteins of shoots and roots of two cultivars of Rapeseed  
—A. Loni, A. Hsanvand and V. Yakhchi
- 1248–1256 Clustered error control using cross layer design reliable routing for efficient agriculture monitoring  
—M. Parameswari and T. Sasilatha
- 1257–1262 Study expression of Fox3, Gata3, T-bet markers using immunohistochemical technique in normal and immunocompromised mice after exposed to *Penicillium marneffe* an experimental study  
—Milad A. Mezher
- 1263–1266 Effect of Neem (*Azadirachta indica*) bark extract on accessory reproductive organs in male albino mice  
—Anju Puri
- 1267–1277 Seasonal variation of physico-chemical parameters of Tamirabarani river and Estuary water Thoothukudi District, Tamil Nadu, India  
—P. Subramanian and G. Vijayakumar
- 1278–1286 Production of biofuels as alternative sources of energy from various raw materials  
—Monika Sharma, Ritu Kumari Singh and Chandra Kant Sharma
- 1287–1293 A comparative study on the performance of Microbial Fuel Cell (MFC) using the substrate of Tannery Effluent inoculated with microbial cultures of *E. coli* and *Shewanella putrefaciens* under batch mode  
—S. Jayanthi and S. Jothi Venkatraman
- 1294–1301 Effect of latent storage geometry on stratification in domestic solar water heater  
—C. Sivakandhan, G. Murali and P. Suresh Prabhu
- 1302–1308 Grey water treatment using novel technique of Aerobic Brickbat Grit Sand (ABGS) purifier system  
—Priyanand Agale and Parag Sadgir
- 1309–1313 Effect of stone dust on certain trees growing around stone crusher centre Parichha, district Jhansi (U.P.) India  
—Neel Ratan and U.N. Singh
- 1314–1320 Assessment of industrial wastewater and groundwater samples using natural adsorbents for treatment  
—Shalini and Pratibha Naithani
- 1321–1326 Improving energy proficiency and trust worthiness for power plant monitoring in WSN  
—Sathiyaseelan Rathinavel
- 1327–1332 Assessment of ground water quality near municipal solid waste landfill by weighed arithmetic water quality index method  
—G. Manjula and S. Revathi

- 
- 1333–1341 Environment friendly synthesis of silver nanoparticles and its application for reducing the environmental pollution and energy conservation in diesel engines  
—C. Chinmasamy and P. Tamilselvam
- 1342–1345 Sharpunkha (*Tephrosia purpurea*) and Tuba root (*Derris elliptica*) as alternative medicines for innumerable diseases and disorders in Ayurveda – A review  
—Asit Kumar Pandey, Amresh Chandra Pandey, Shambhu Saran Kumar, Vinod Kumar Pandey<sup>2</sup> and Sheela Barla
- 1346–1353 Hydrochemical Elucidation of groundwater for drinking and irrigation purposes – A case study of Nandi river basin, Tamilnadu, India  
—K. Prabhu and R. Sivakumar
- 1354–1357 Feasibility study on red mud (Industrial waste) as a substitute for soil, cement and its environmental impact  
—M.P. Sureshkumar and G. Vennila
- 1358–1363 A report on the mycophagy in *Bolitotherus cornutus* (Panzer) from the tropical rain forest of Malaysia  
—Meghma Bera and Narayan Ghorai
- 1364–1370 Kinetic modeling of growth on biodegradation of Naphthalene using *Rhodococcus* sp.  
—J. Jegan, T. Bhagavathi Pushpa, S. Praveen and B. Nithyalakshmi
- 1371–1376 Experimental investigation and study of Environmental FMEA on sewer pipe joints of chemical industries  
—A. Arul Kumar and R.A. Sankaran
- 1377–1387 An ecological longitudinal perspective of Pulicat Estuary, India  
—S. Jerard Majella Francis and I. Arul Aram
- 1388–1392 Response of Surpunkha (*Tephrosia purpurea*) as a non conventional pesticide in Agriculture for eliminating unwanted fishes  
—Asit Kumar Pandey, Amresh Chandra Pandey, Shambhu Saran Kumar, Vinod Kumar Pandey and Sheela Barla
- 1393–1397 Sustainable structural retrofitting of corroded concrete using basalt Fibre composte  
—S. Thahira Banu, G. Chitra, R. Gobinath, P.O. Awoyera and E. Ashokkumar
- 1398–1405 Tiger reserves and Tribal ecologies: Articulating the eco-cultural landscapes of the Mannan (India)  
—Gnana Bharathi B.
- 1406–1408 The study of different types of pollination on yield of Bam “Mozafaty” wet date  
—Reza Kamrani and Mohammadreza Yavarzadeh
- 1409–1416 Potentially humid identification of environmental issues of zones by sig in an arid region (case of basin overturning of Saoura, West South Algeria)  
—Badaoui Imane, Tamali Mohamed, Mekkaoui Abdrahmane and Merzougui Touhami
- 1417–1421 Isolation and identification of hydrocarbon degrading bacteria from petroleum contaminated soil of Assam  
—Archana Kalita, Manab Deka, Aniruddha Sarma and Deepali Deka
- 1422–1430 The effect of exclosure on floristic composition and vegetation diversity in dry rangelands (Case study: Southern rangelands of markazi province in Iran)  
—Jamal Bakhahi, Seyed Akbar Javadi, Ali Tavili and Hossein Arzani
- 1431–1438 Enhancing environmental management of small islands for sustainable tourism: case study of Derawan Island, East Kalimantan, Indonesia  
—Luchman Hakim, Mardiany and Sun-Kee Hong

- 
- 1439–1443 Characterization of biomass quality of high yielding Napier grass species for forage applications  
—*Dana Mohamed Asraf, Vijaya Ilango and S. Ramachandran*
- 1444–1450 Coral lives of Malaysian Peninsula- A multifaceted Review  
—*Tapash Rudra*
- 1451–1459 *In vitro* inoculation of phosphate-solubilizing microorganisms in seedlings of *Mangaba* (*Hancornia speciosa* GOMES)  
—*Juliana Silva Rodrigues Cabral, Edson Luiz Souchie, Flávia Dionísio Pereira and Fabiano Guimarães Silva*
- 1460–1465 Studying state of soils at construction sites of Shipyard near Kuryk (Kazakhstan)  
—*Symbat Koibakova, Gusman Kenzhetayev, Samal Syrlybekkyzy, Nurgul Janaliyeva, Lyailim Tazhanova and Zhansayle Altybayeva*
- 1466–1470 *Talaromyces* sp. are associated with Shisham (*Dalbergia sissoo* Roxb.) Nursery disease in Pantnagar, A Terai region of Western Himalayas  
—*Hemant Dasila, Samiksha Joshi, Manvika Sahgal and Salil Tiwari*

# Analysis of puddles in Swamp areas of Banyuasin District using the image Lands at 8 by NDWI method

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## ABSTRACT

Stagnant water and flooding in a region generate the disruption of activities from the area use. The swamp area is one of the areas that is always flooded in which nowadays the development in the swamp area is more massive, so that required road infrastructure to support regional development is available. The road construction planning needs to take attention to the areas of inundation that exist in the swampy areas so that the road can be built by the basic function of the swamp. The use of remote sensing technology is an economic alternative that can be used in the introduction of the puddles. In this study, the classification of puddles will be done using the Landsat 8 image with the Normalized Different Wetness Index (NDWI) method by using the combination on band composite 53. The results shows that the classification by obtaining the range of reflectance value in which (-0,7851) – (-0,404) for non-water body, (-0,4041) – (-0,2021) for low puddles, (-0,2021) – 0,0733 for medium puddles, 0,0733 – 0,1057 for high puddles, and 0,1057 – 0,8726 for rivers.

**Key words :** Stagnant water, Puddles, Swamp, NDWI, Remote Sensing

## Introduction

The development of areas for infrastructure development is constrained by vulnerability to water, wind, erosion, stagnant water, and flooding. Stagnant water and flooding affect the carrying capacity of the land due to existing physical condition. It can be seen that the flatter a region in topography and the closer to the sea, the more likely to be the occurrence of puddles and floods. The considerations of topography in swamp areas are not based on the slope and altitude on the soil surface because most of the swamp areas are flat areas (Indrayani, *et al.*,

2016). The stagnant water and flooding generate the problem in the activities of land use (Sukarman *et al.*, 2013). The swamp area is one of the areas that is always flooded in which nowadays the development in the swamp area is more massive done due to the decreasing of productive area. In addition, the government develops the swamp area in several sectors such as agriculture, plantation, and fishery (Suriadikarta dan Sutriadi, 2007; Arsyad *et al.*, 2014). The swamp area becomes one of the alternatives in the development of road infrastructure. However, the existence of the road infrastructure should take in attention especially in the environmental aspects

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because the engineering should retain the role and function of wetland ecosystem without reducing the function and benefits of the road network system to be built in the swamp area (Harry, 2007; Suryoto *et al.*, 2017).

The location of inundation in a region can be known through immediate analysis to the studied area. However, the direct measurement requires a high cost. Remote sensing is one method that can be used to illustrate the puddles using Landsat with the approach of specific bands (Huang *et al.*, 2014; Xia *et al.*, 2017).

Nowdays, Landsat program has released the Landsat 8 in remote sensing technology that has sensor of Onboard Operational Land Imager (OLI) sensor and Thermal Infrared Sensor (TIRS) which has 11 channel number consisting of 9 channels (bands 1-9) residing on OLI and 2 channels (band 10 and 11) on TIRS (Lapan, 2015). Geographic Information System (GIS) using remote sensing technology is one of the economic alternatives in the determination of potential land cover (Karakus *et al.*, 2015; Wondrade *et al.*, 2014). Some methods used in interpreting the image using wavelength are NDVI

(Normalized Different Vegetation Index), NDWI (Normalized Different Wetness Index), and NDSI (Normalized Different Soil Index) (Gandhi *et al.*, 2015; Deng *et al.*, 2015; Haikal, 2014). NDWI is remote sensing technology based on the sensitivity indicator to changes in leaf water content (Haikal, 2014). The result of puddles classification is a thematic map of puddles height that used as the initial stage of road planning determination guideline in the swamp area.

## Materials and Methods

### Study Area

The research was conducted at swamp area in Banyuasin regency which has the wide area of 1,183,299 ha or approximately 12.18% of total area of South Sumatera Province. It is located in the coordinates between  $1^{\circ} 37'32.12''$  to  $3^{\circ} 09'15.03''$ LS and  $104^{\circ} 02'21.79''$  to  $105^{\circ} 33'38.5''$ BT. Banyuasin regency consists of 80% wet lowland with slope 0 – 8% of 1,181,610 ha and 8 – 15% of 1,689 ha (Kabupaten Banyuasin, 2011). The study area can be seen in Fig. 1.

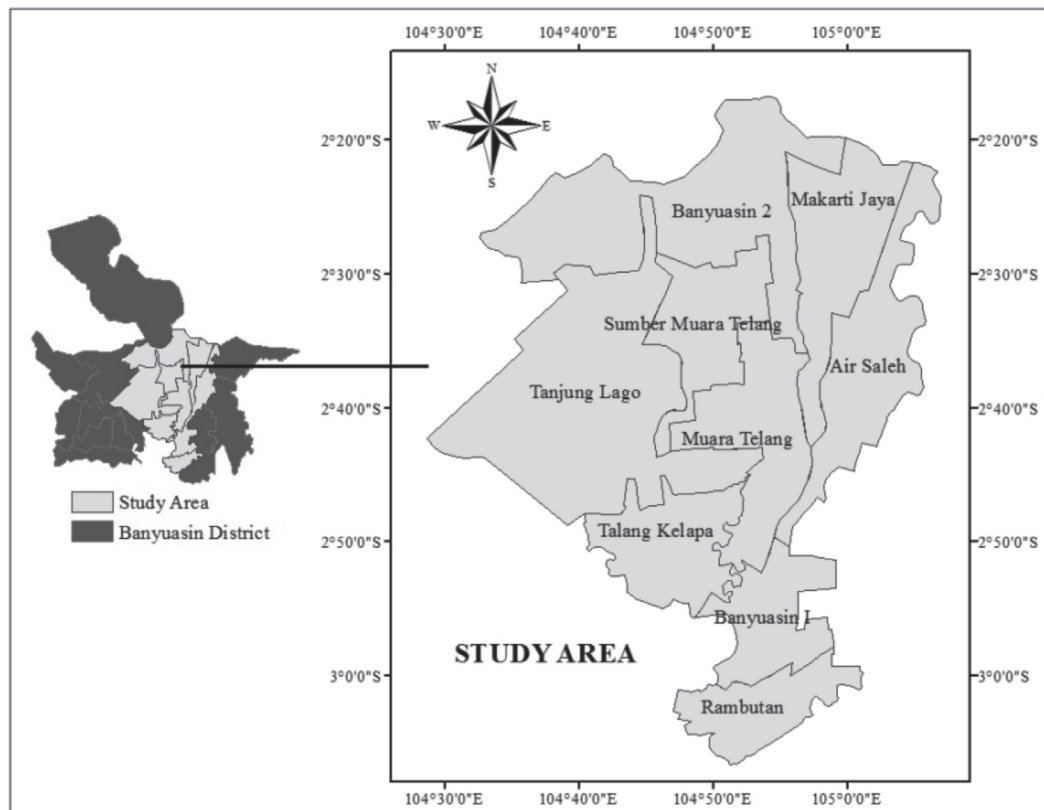


Fig. 1. Study Area

### Classification Method

To obtain the thematic map of the puddles classification, it is done by using the remote sensing technology through Landsat 8 image interpretation which is downloaded from the United States Geological Survey on the scene: path 124/row 062.

The stages of data processing including: (1) pre-processing stage (giving the limit space of image that serves to the area of research and reduce the size of image files as well as geometric and radiometric correction); (2) stages of data processing (color composite, digital image interpretation for sharpening, smoothing filter, contrast, and multi-spectral classification in Landsat 8 image, and NDWI transformation); and (3) the field test stage to check the truth of the classification result using GPS navigation tool.

The inundation classification was carried out using *Normalized Different Water Index* (NDWI) method combining band 3 and band 5 in detecting the inundation that occurred. Visible channels on Landsat 8 (band 1-4 OLI) at the time of flood will increase the value of reflectance whereas the infrared channel (NIR, SWIR, MIR) will be decreased. The transformation of NDWI can use the equation below.

$$\text{NDWI} = (\text{Band 3} - \text{Band 5}) / (\text{Band 3} + \text{Band 5})$$

The characteristics of OLI sensor on satellite Landsat8 has 9 bands which shown table 1 below.

## Results

### Classification of the puddless based on spectral values

The interpretation of the puddles will be analyzed based on NDWI value with the combination of 3 bands of green spectrum (visible) at 0.525-0.600  $\mu\text{m}$ . The land surface object will have varied spectral responses when the land is inundated or not inundated. At the flood, there will be an increase in visible band (1 – 4 OLI) whereas the infrared band (NIR, SWIR) will be decreased.

To conduct the interpretation of the puddles in the study area, the analysis of Landsat 8 image which taken in December was used. These results represent the data in the rainy season. The sampling point to determine the puddles were drawn using a 53 band composite that represents the aquatic and non-aquatic regions. Using 53 band combination, it would be distinguished by aquatic and non-aquatic

areas. Because at the wavelength of 0.4 – 0.5  $\mu\text{m}$ , the water will be high and tend to decrease until it disappears in the NIR spectral range with a wavelength of 0.8  $\mu\text{m}$  upwards. The sample points which taken to determine the average reflectance value for the non-aquatic area are seen in fig. 2.

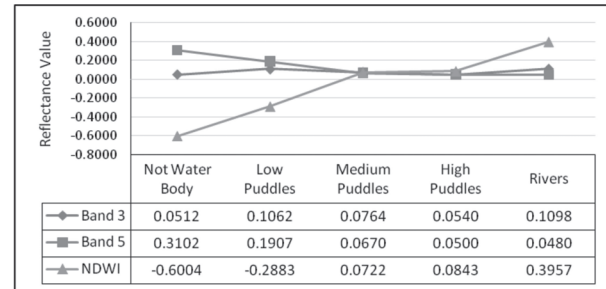


Fig. 2. The reflectance values of Band 3(Green), Band 5 (NIR) and NDWI.

Fig.2 shows the average reflectance value in band 3 (green) and band 5 (NIR). The value distinguishes non-aquatic and aquatic regions for low, medium, high, and rare interior ponds.

Fig. 3 represents the spectrum of band 3 (green) with wavelength 0.525 – 0.600  $\mu\text{m}$  in which shows the high reflectance value at the puddles. The area has 0.1044 and 0.0512 as the highest and the lowest reflectance value, respectively. In the other hand, the NIR spectrum in band 5 with wavelength 0.845 – 0.885  $\mu\text{m}$  shows the high reflectance value in non-aquatic regions which is 0.3102  $\mu\text{m}$  and the reflectance value will continue to decrease in the puddles that shows 0.0480  $\mu\text{m}$ .

The NDWI value shows the difference between the NIR and the visible band. The higher the value of the NIR difference in band 5 and band 3, the

Table 1. The characteristics of OLI sensor on satellite Landsat 8

Band	Wavelength ( $\mu\text{m}$ )
Band 1 (Coastal aerosol)	0.433 – 0.453
Band 2 (Blue)	0.450 – 0.515
Band 3 (Green)	0.525 – 0.600
Band 4 (Red)	0.630 – 0.680
Band 5 (NIR)	0.845 – 0.885
Band 6 (SWIR 1)	1.560 – 1.660
Band 7 (SWIR 2)	2.100 – 2.300
Band 8 (Panchromatic)	0.500 – 0.680
Band 9 (Cirrus)	1.360 – 1.390

(Lapan, 2015).



NDWI value will be smaller and vice versa. The NDWI value can be seen in Fig. 2.

The NDWI value with a combination of band 3 (visible) and band 5 (NIR) will show the positive value to the puddles. The NDWI will show the higher value if the area has the high degrees of wetness and vice versa. Furthermore, The NDWI classification is divided into 5 classes which shown in Table 2, and the results of the classification of puddles based on the reflectance value can be seen in Fig. 3.

**Table 2.** The NDWI classification .

Class	Reflectance value
Not a water body	(- 0.7851) – (- 0.4041)
Low Puddles	(- 0.4041) – (- 0.2021)
Medium Puddles	(- 0.2021) – 0.0733
High Puddles	0.0733 – 0.1057
River	0.1057 – 0.8726

The accuracy in the interpreting of the puddles was carried out using a confusion matrix. The confusion matrix will match the data of inundation classification with the result data of field cross check conducted by direct observation. In addition, the field cross-check also supported by the supporting secondary data, interview, etc.

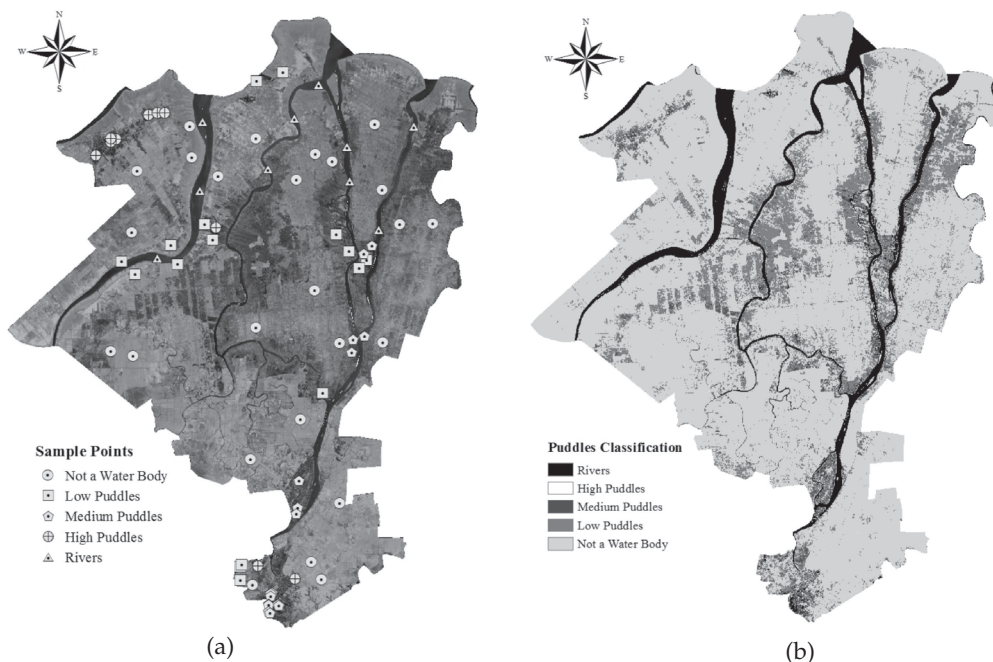
### Puddles accuracy test

The survey was conducted from February to April, 2017 at several subdistricts such as Talang kelapa, Tanjung lago, Muara telang, Rambutan, and Banyuasin I. The description of the puddle at the sampling point can be seen in Fig. 4.

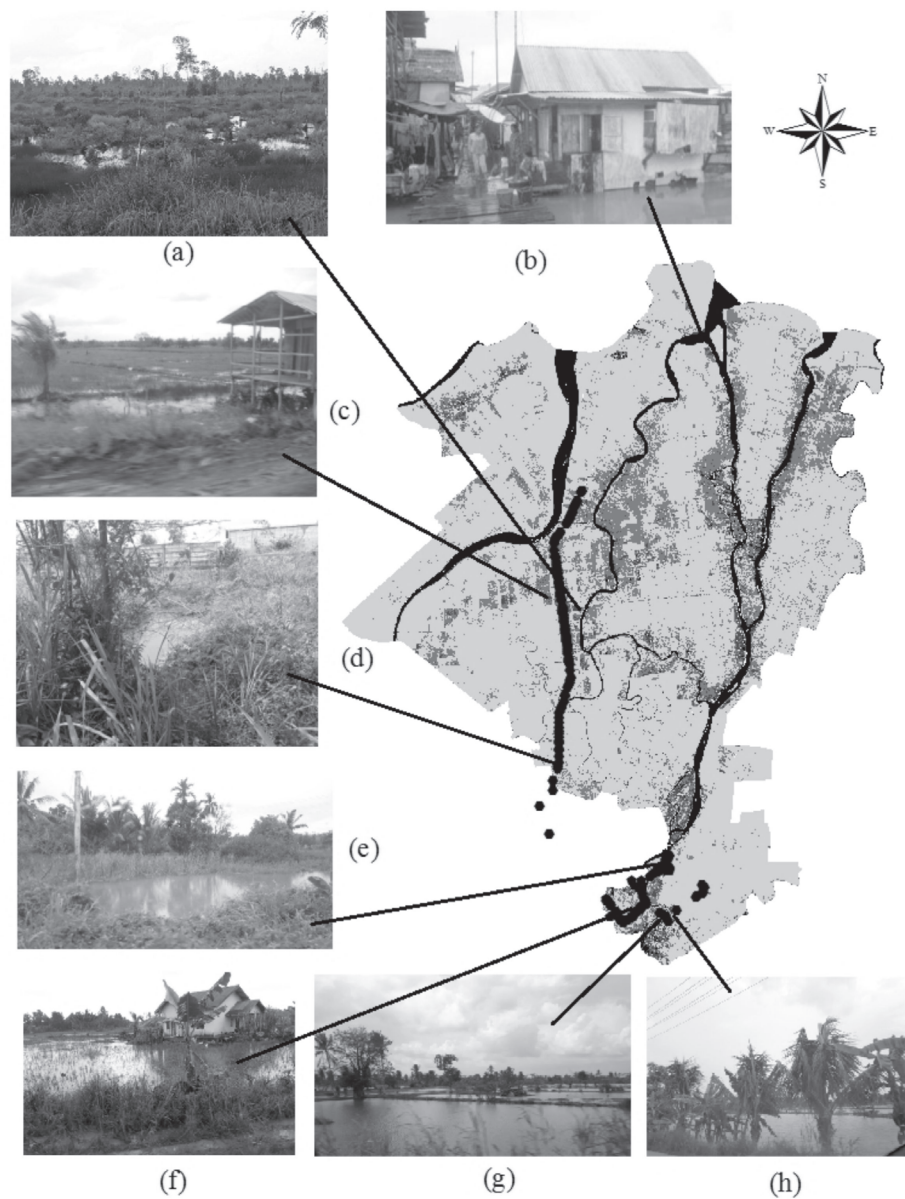
Table 3 shows the level of accuracy of the result of puddle height classification using Landsat 8 with NDWI method. The results show that the percentages of the over all rate are 91.77% which indicate that the result of puddle classification can be used in the generating of the water level thematic maps based on the height of the ground surface.

The height of puddles was also obtained from the interviews with several sources including staff and secretary of subdistricts government in Talang kelapa subdistrict, Kenten laut, Rambutan, Banyuasin I, and staff of the regional disaster management agency office of South Sumatera Province, Head of agency and employees of the regional disaster management agency in Banyuasin regency, as well as residents around the study area.

The classification of water level to the height of the soil is classified into 3, i.e.(1) the height of 0-20 cm means that the stagnant water floods the rice fields and the swamp areas. (2) The height of 20 – 50 cm means stagnant water inundated rice fields,



**Fig. 3.** Puddles identification on the composite band 53. (a) sample point of determination based on reflectance value, (b) classification result of the puddles.



**Fig. 4.** Cross Check of the result of puddles, (a) the swamp area in Tanjung Lago subdistrict; (b) the inundation in Sungsang Banyuasin II; (c) The puddle in paddy field of Tanjung Lago subdistrict; (d) The swamp area in Talang Kelapa subdistrict; (e) The puddle area in Banyuasin I; (f) The puddle area in the settlement of Rambutan sub-district; (g) The puddle in paddy field of Rambutan subdistrict; (h) the puddle in paddy field of Sungai Dua.

**Table 3.** Confusion Matrix on Puddles Classification

Description			Reference Data (Field Data)		Sum	Accuracy's User(%)
			Puddles	Non Puddles		
Classification Data	Puddles		58	7	65	89.23
	Non Puddles		6	87	93	93.55
Sum			64	94	158	
Accuracy's Producer (%)			90.63	92.55		91.77

swamps, and access roads; (3) > 50 cm means that the stagnant water inundated rice fields, swamps, access roads, and settlement.

## Discussion

Band 5 and band 3 could be used to determine the puddles. The reflection on the puddle will be affected by the water base material or the material covered by the puddle. The absorption characteristics will be influenced by the type, size, and type of material which are present in the puddles. On the other hand, the water depth will be distinguished from the level of color brightness in the water area. The darker the color of the puddle will show the greater the water depth and the bright color indicates the lower water depth. Water with a high depth will absorb more wavelength so that the reflect the spectral value will be lower compared to the low depth.

Du *et al.* (2014) have evaluated the potential of Landsat-8 OLI image for land surface water mapping (LSWM) in the Yangtze Basin and Huaihe River Basin, China. The results showed that OLI image could be used accurately and easily for LSWM. Furthermore, Xu (2006) have used NDWI with mid-infrared bands such as Landsat TM ribbon 5 for near-infrared bands used in the modified NDWI (MNDWI) and reported that the MNDWI could enhance the open water feature while efficiently pressing and removing built-up ground noise as well as soil and vegetation noise. Enhanced water information using NDWI is often mixed with built-up land noise, and the extracted water area is too high. Thus, MNDWI is better suited for improving and extracting water information for aquatic area against a background dominated by areas of built land because of its advantages in reducing and even removing land noise from NDWI.

Some considerations in determining road trace as the initial stage of road planning in the swamp area based on topography and hydrology condition are topography condition commonly used in deciding road trace. However, the land altitude or slope can not be applied in deciding road trace in swamp area since the swamp area has relatively flat area altitude. Furthermore, the swamp area is usually flooded so that the topography factor must always be considered together with the hydrological factor by considering water level to ground level.

## Conclusion

The classification of the puddles obtains a range of reflectance values of (-0.7851) – (-0.4041) for non-aquatic regions, (-0.4041) – (-0.2021) for low puddle areas, (-0.2021) – 0.0733 for medium puddles with the height 20-50 cm (0.0733 – 0.1057) for high puddles, and (0.1057 – 0.8726) for river. In general, Banyuasin has the low inundation level and only few areas have high puddle areas.

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